भारतीय मानक
Indian Standard

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(Reaffirmed 2019)

भूकृत्रिम — केपिलरी फलो टेस्ट द्वारा भूवस्त्रादि के छिद्र आकार विशेषता की परीक्षण विधि

Geosynthetics — Method of Test for Pore Size Characteristics of Geotextiles by Capillary Flow Test

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July 2015 **Price Group 4**

Geosynthetics Sectional Committee, TXD 30

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Textile Division Council.

In the preparation of this standard assistance has been drawn from ASTM D6767 – 11 ‘Standard test method for pore size characteristics of geotextiles by capillary flow test’, issued by the American Society for Testing and Materials, USA.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GEOSYNTHETICS —METHOD OF TEST FOR PORE SIZE CHARACTERISTICS OF GEOTEXTILES BY CAPILLARY FLOW TEST

1 SCOPE

1.1 This test method covers the determination of the pore size distribution of geotextile filters with pore sizes ranging from 1 to 1 000 µm.

NOTE — The accuracy of this procedure has been verified up to a maximum pore size of 200 µm. Above this value accuracy has been found to be equipment dependent and shall be verified by the user through checks on materials with known opening sizes.

1.2 The test method measures the entire pore size distribution in terms of a surface analysis of specified pore sizes in a geotextile, defined in terms of the limiting diameters.

2 REFERENCES

The following standards and special publication are necessary adjuncts to this standard.

IS No.	*Title*
1070 : 1992	Reagent grade water — Specification (*third revision*)
13321 (Part 1) : 1992	Glossary of terms for geosynthetics : Part 1 Terms used in materials and properties
SP 45 : 2014	Handbook on glossary of textile terms

3 TERMINOLOGY

For the purpose of this standard the following definitions and those given in SP 45 and IS 13321 (Part 1) shall apply.

3.1 Bubble Point Pore Size (O_{98}) — The largest effective pore diameter detected by the sudden increase of flow rate at the beginning of the wet test.

3.2 Pore Constriction (*O*) — Diameter of a circle having the same area as the smallest section of a given pore.

3.3 Pore Size (*Oi*) — Capillary equivalent pore diameter for which the percent of total pore diameters '*i*' in a given geotextile based on the surface occupied by the pores are smaller than or equal to that diameter.

3.4 Pore Size Distribution (PSD) — Percent cumulative distribution of the complete range of pore sizes with in a given geotextile based on the surface occupied by the pores.

3.5 Wetting Liquid — Liquid used to submerge the geotextile specimen prior to beginning the test.

4 PRINCIPLE

4.1 Geotextile filters have discrete pores from one side to the other of the geotextile. The bubble point test is based on the principle that a wetting liquid is held in these continuous pores by capillary attraction and surface tension, and the minimum pressure required to force liquid from these pores is a function of pore diameter.

4.2 A fluid-wet geotextile will pass air when the applied air pressure exceeds the capillary attraction of the fluid in the pore constriction. Smaller pore constrictions will exhibit similar behaviour at higher pressures. The relationship between pore size and pressure has been established for water.

4.3 By comparing the gas flow rates of both a wet and dry geotextile at the same pressures, the percentage of the flow passing through the filter pores larger than or equal to the specified size may be calculated from the pressure-size relationship. By increasing pressure in small steps, it is possible to determine the flow contribution of very small pore size increments by difference.

5 SIGNIFICANCE AND USE

5.1 This test method may be used to:

a) determine the pore size distribution of a geotextile,

b) determine the maximum pore size of a geotextile,

c) determine the mean flow pore size of a geotextile,

d) determine the effect of processes such as calendering or needle punching upon the pore size distribution,

e) determine the effect of compression upon the pore size distribution of a geotextile, and

f) determine the gas flow rate of a geotextile, and thereby its gas flow capability.

5.2 The pore size distribution test is significant not only for indicating pore sizes, but may also indicate a damaged, contaminated, or clogged geotextile.

6 APPARATUS

6.1 Clean gas pressure source, with regulation (filtered air or nitrogen).

6.2 Pressure transducer, U-tube manometer or gauge (or set of gauges), covering the necessary pressure range for the pore sizes under study (*see* Table 1).

NOTE — Pressure measurements shall be installed immediately upstream (for example, within 5 mm) of the sample holder.

6.3 Closed filter holder (*see* Fig. 1).

NOTE — The filter holder shall be checked for leaks by placing a geo-membrane in the holder and increasing the pressure to 70 kN/m^2 and holding it for a period of 1 min.

6.4 Metal Punch, used to cut a suitable size geotextile from the test sheet to fit the test filter holder.

6.5 Set of Flowmeters, covering the range from 0 to 5 000 l/min.

NOTE — Four flowmeters with flow rates of 0 to 0.4, 0 to 2.5, 0 to 25, and 0 to 100 l/min, placed in a parallel arrangement to cover the range of flow rates anticipated are recommended for geotextiles.

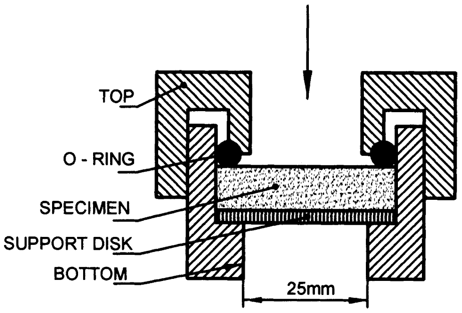

Fig. 1 Closed Filter Holder

6.6 In-line fluid trap, to protect the flowmeters from the fluid.

6.7 Appropriate fittings, hose, connectors, piping, to assemble apparatus as shown in Fig. 2 and Fig. 3.

6.8 ***x-y* Recorder**, to assist in graphing results of mean flow pore test.

7 TEST SPECIMENS

As a laboratory sample for acceptance testing, take a full width swatch 1 m long from the end of each roll of fabric in the lot sample, after first discarding a minimum of 1 m of fabric from the very outside of the roll. Cut

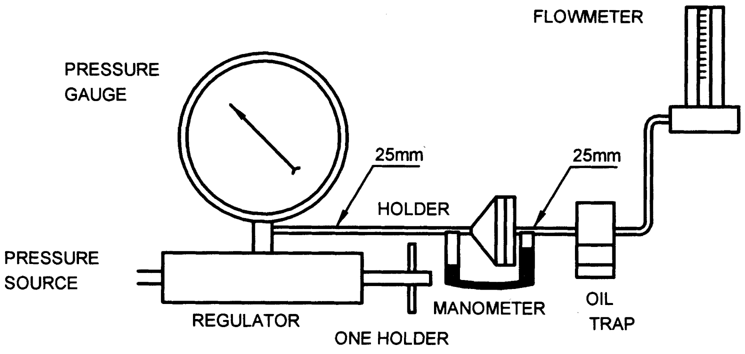

Fig. 2 Setup for One Holder

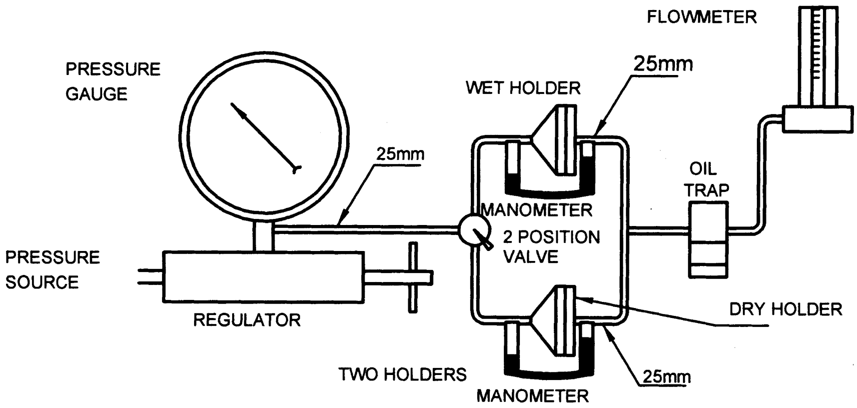

Fig. 3 Setup for Two Holders

Table 1 Pressure Ranges Required

(*Clauses* 6.2 *and* 9.8)

Sl No.	Fluid Used	Pore Size Range to be Investigated				Surface Tension dynes/cm at 25°C
		≥ 100 µm	≥ 50 µm	≥ 10 µm	≥1 µm	
i)	Water	0 to 2.5 kPa	0 to 7.5 kPa	0 to 25 kPa	0 to 200 kPa	72
ii)	Petroleum distillate				0 to 100 kPa	30
iii)	Mineral oil				0 to 75 kPa	34.7

five specimens from each swatch in the laboratory sample with each specimen being cut to fit the appropriate sieve pan. Cut the specimens from a single swatch spaced along a diagonal line on the swatch.

8 SPECIMEN PREPARATION

Weigh the specimens, submerge them in water for 1 h, and then allow the specimens to air dry at the standard atmosphere for testing. The specimen shall be completely dry before testing. Weigh the specimen after air drying until a constant weight equal to or less than the initial weight of the specimen is achieved. Air may be blown over the specimens with a fan to facilitate drying.

9 WETTING LIQUIDS

9.1 Purity of Reagents — Reagent grade chemicals shall be used for wetting liquids in all tests.

9.2 Water, Grade 1, conforming to IS 1070.

9.3 Denatured Alcohol

9.4 Mineral Oil, such as USP liquid petrolatum heavy, with surface tension of 34.7 dynes/cm at 25°C.

9.5 Porewick™

9.6 Silwick™

9.7 Galwick™

NOTE — The reagents names at **9.5**, **9.6** and **9.7** are registered trade-marks from Porous Material Inc.

9.8 Clean gas pressure source, with regulation (filtered air or nitrogen).

NOTE — Table 1 lists the nominal surface tension of these liquids at 25°C. There is a potential influence of the liquid on a measurement of pore size, which shall be taken into account by users through verification tests on materials with known pore size.

10 PROCEDURE FOR ONE HOLDER (*see* Fig. 2)

10.1 Place a dry geotextile sample disk in the geotextile holder.

10.2 Close the holder and apply gas pressure in increments.

10.3 Plot gas flow *versus* gas pressure over the intended range of use.

10.4 Reduce gas pressure and remove the geotextile from the holder.

10.5 Completely wet the geotextile by submerging it in wetting liquids (for example, water) for a period of 30 min. Replace the wet geotextile in the holder, and apply a slight pressure, checking to see that a tight seal exists. This pressure shall not exceed the bubble point pore size.

10.6 Plot the fluid-wet filter gas flow *versus* pressure on the same coordinates as for the plot made in accordance with **10.3**.

10.7 Reduce the pressure, remove the filter, and clean the holder for the next test.

11 PROCEDURE FOR TWO HOLDERS (*see* Fig. 3)

11.1 Place a dry geotextile in the holder to be used exclusively for dry geotextiles.

11.2 Wet a geotextile of the same type and lot as the geotextile used in **11.1**, in reagent and place it in a holder to be used exclusively for wet geotextiles.

11.3 Apply gas pressure to the dry geotextile and plot gas flow versus gas pressure.

11.4 Change the two position valve to apply gas pressure to the wet geotextile holder and record the first gas flow as detected by the capillary tube as the bubble point. Switch to flowmeters and plot fluid-wet gas flow *versus* gas pressure.

12 CALCULATION OF PORE SIZE, PORE SIZE DISTRIBUTION AND FREQUENCY

12.1 The calculation of pore size is based on the equilibrium of forces as shown by following equation 1:

$$\pi O_i \gamma B \cos\theta = \left(\frac{\pi}{4}\right) O^2 P \qquad \dots (1)$$

where

O_i = pore size, in µm;

γ = surface tension, mN/m, in dynes/cm;

P = pressure, Pa or cm Hg; and

B = capillary constant.

The left-hand side of equation 1 is the resisting force developed from surface tension acting between the liquid and the sidewalls of a pore constriction of diameter O. The right-hand side of equation 1 is the driving force developed from the applied pressure multiplied by the area of the pore constriction. Equation 2 is derived by rewriting equation 1 to solve for O.

$$O = \frac{4TB\,(\cos\theta)}{P} \qquad \ldots (2)$$

If the test liquid is known to wet the geotextile completely, and $\theta = 0$, then:

$$O = \frac{C\gamma}{P} \qquad \ldots (3)$$

where

C = constant, 2 860 when P is in Pa, 2.15 when P is in cm Hg, and 0.415 when P is in psi units.

NOTE — If the contact angle is greater than zero, the calculated effective pore size will be larger than the actual effective pore size rating.

12.2 Select the limits of the pore size range being evaluated. Substitute the limits individually into the pore size *versus* pressure formula, obtain their respective pressures and plot the results. From the test results, determine the wet and dry flows at each pressure measured in the wet test and extrapolated from the dry curve over the pressure limits (pore size limits of the range) as shown in Fig. 4.

12.3 The PSD of a geotextile is found by using equation 4 at each different pressure and flow rate measured.

$$\%\ \text{Finger} = \left[1 - \frac{(\text{wet flow rate})}{(\text{dry flow rate})}\right](100) \qquad \ldots (4)$$

NOTE — Since the change in pore size per unit change in applied pressure is greatest at large pore sizes and diminishes hyperbolically, repeatability and reproducibility increase accordingly with applied pressure.

13 REPORT

13.1 Report the geotextile identification, date and time of test, and all pertinent general testing conditions.

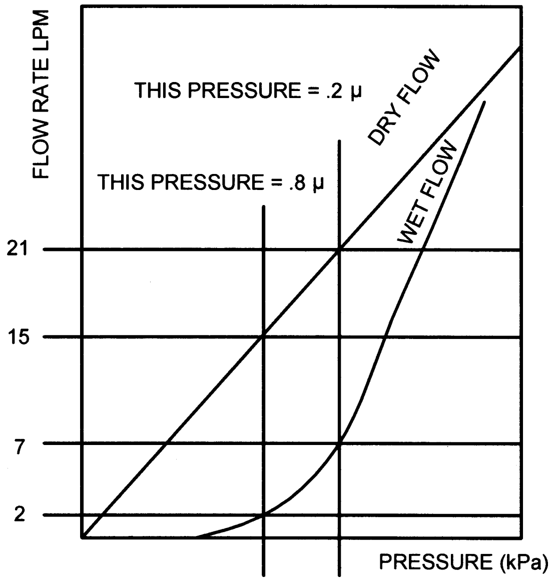

FIG. 4 EXAMPLE OF PORE SIZE FREQUENCY DETERMINATION

13.2 Indicate in a table for each tested specimen: Bubble Point (O_{98}) and values (O_{95}, O_{90}, O_{85}, O_{60}, O_{30}, O_{15}, O_{10}, O_5). Indicate the mean values and the coefficient of variation for each pore size.

13.3 Provide a complete pore size distribution curve showing the pore size on the x-axis and percent finer than on the y-axis as shown in Fig. 5.

14 PRECISION AND BIAS

14.1 Results shall not differ from the mean by more than the following amounts:

Pore Size Range	*Repeatability, Percent Same Operator and Apparatus*	*Reproducibility, Percent Different Operator and Apparatus*
Greater than 100 μm	2	4
10 to 100 μm	1	2.5
1 to 10 μm	0.5	1

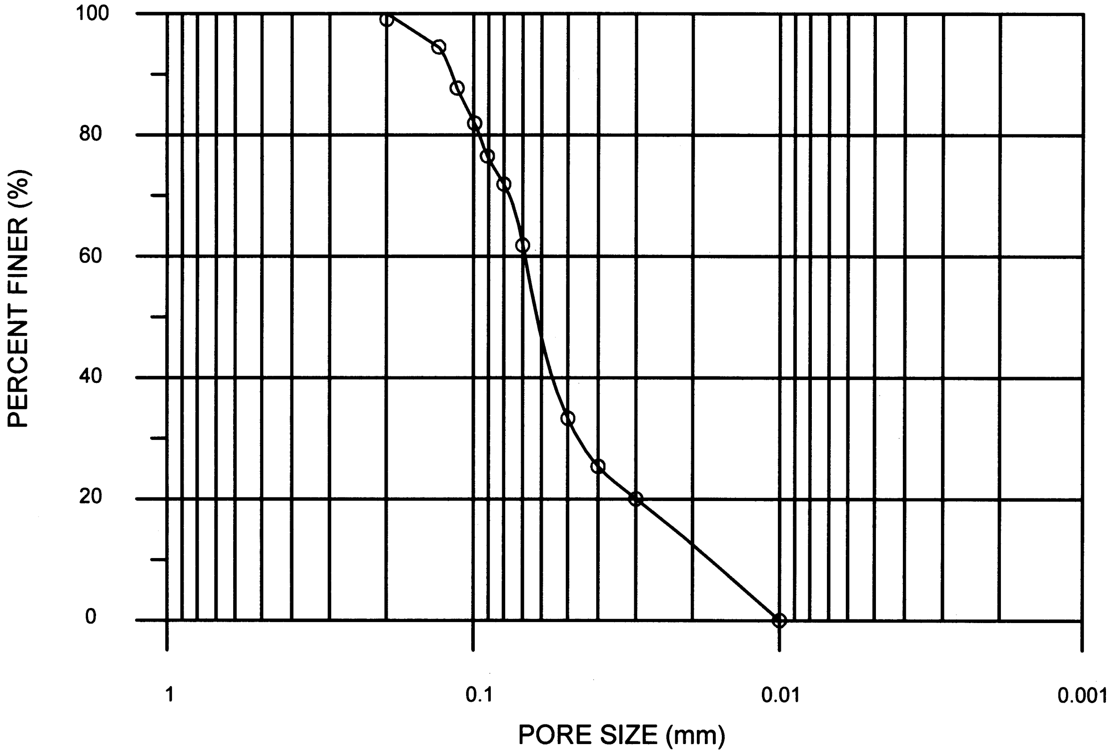

FIG. 5 TYPICAL GEOTEXTILE PORE SIZE DISTRIBUTION CURVE

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Geosynthetics Sectional Committee, TX 30

Organization	*Representative(s)*
The Bombay Textile Research Association, Mumbai	Dr A. N. Desai (***Chairman***) Shri V. K. Patil (*Alternate*)
Brahmaputra Board, Guwahati	Representative
Business Coordination House, New Delhi	Shri Samir Gupta Shrimati Ritika Gupta (*Alternate*)
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Central Soil and Materials Research Station, New Delhi	Shri Nripendra Kumar Shri Manish Gupta (*Alternate*)
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